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SOME NEMATODES OF THE FAMILY *TYLENCHIDAE* WHICH DO NOT POSSESS A VALVULAR MEDIAN ESOPHAGEAL BULB

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The collection of nematodes on which this paper is based has accumulated at the Salt Lake City Station of the Division of Nematology during the past 20 years. These specimens have been secured from the great quantity of plant and soil material submitted for examination and identification by various state, government and private agencies and from the extensive faunistic collections made at this station.

As a matter of convenience to the reader, information has been included on related species previously described and certain others of doubtful position. As will be noted, the classification of this group is in a most unsatisfactory state and will remain so until the nemic fauna has been more carefully and extensively studied, for there is no doubt that only a small portion of the existing genera and species are here represented.

Many of the species have been found associated with the roots of alfalfa, cotton, sugar-beets and other cultivated plants but, with the possible exceptions of *Hexatylus viviparus* Goodey, 1926, and *Neotylenchus abulbosus* Steiner, 1931, none is suspected as being of economic importance. Their generally small spears doubtless preclude any possibility of their being able to puncture the cell walls of the higher plants and feed upon their contents unless they invade the cells as true endoparasites. Since they are not known to be endoparasites of either the roots or stems of the higher plants it seems most probable that they feed on the microflora of the soil, such as algae and fungi. Usually they are found in very small numbers which eliminates them as being of any particular importance under the conditions in which they have been observed.

Three distinct types are represented in the species presented which

are here designated as the new subfamilies *Neotylenchinae*, *Paurodontinae*, and *Nothotylenchinae*. These subfamilies are tentatively placed under the family *Tylenchidae* but the *Neotylenchinae* and *Paurodontinae* doubtless will eventually be raised to a family rank because they possess certain characteristics which distinguish them from all other tylenchs.

KEY TO SUBFAMILIES

1. Basal esophageal bulb bearing a stem-like basal extension ..... *Paurodontinae* n.s.f. p. 50
   Basal esophageal bulb not bearing a stem-like basal extension 2
2. Head framework octagonal..... *Neotylenchinae* n.s.f. p. 38
   Head framework hexagonal..... *Nothotylenchinae* n.s.f. p. 56

Neotylenchinae Thorne, new subfamily

Tylenchidae. Body with a characteristic dense texture which obscures anatomical details to a greater degree than is usual in *Tylenchidae*. Corpus of esophagus somewhat cylindroid without a typical tylenchoid median bulb and valvular apparatus. Dorsal esophageal gland frequently greatly developed. Head region octagonal, the framework divided into 8 sectors, some of which may be greatly modified. Arches of cephalic framework generally much lower than in other *Tylenchidae*, forming a low rounded lip region. There are probably ten cephalic papillae although all of them have not been observed on some species. These are arranged on the two lateral and four submedial lips, six minute ones close to the entrance to the vestibule and four near the margins of the submedial lips. Ovary prevulvar, a rudimentary posterior uterine branch rarely present. Spicula and gubernaculum tylenchoid or of very aberrant types *(Hexatylus fungorum* and *Iotonchium imperfectum)*.

Diagnosis: *Tylenchidae* without a valvular median esophageal bulb. Differentiated from *Nothotylenchinae* by the more dense texture of the body, the octagonal lip region which is divided into 8 sectors, the rare occurrence of a posterior uterine branch and, frequently, the increased size of the dorsal esophageal gland. From *Paurodontinae* it is immediately distinguished by the absence of the stem-like extension of the basal esophageal bulb so typical of this subfamily.

Type Genus: *Neotylenchus* Steiner, 1931.

The subfamily *Neotylenchinae* now includes four genera possessing certain general characteristics which indicate that they have a common, though distinct, relationship. However the anatomical fea-

tures of the esophagi and reproductive systems are very different in these genera, which may indicate they they belong to an exceedingly ancient group of organisms. Considering the apparent rarity of most of the species included in this subfamily it would appear that the group is now in its senility.

KEY TO GENERA OF *NEOTYLENCHINAE*

1. Lip region broadly expanded, spicula angular, gubernaculum absent.....*Iotonchium* Cobb p. 50
   Lip region not broadly expanded, spicula, where known, not angular, gubernaculum present..... 2
2. Esophagus base fused with intestine, not set off in any manner .....*Hexatylus* Goodey p. 48
   Esophagus base set off, bulb-like or with greatly developed glands 3
3. Intestine joining esophagus just back of nerve ring, glands lying free in the body cavity..*Deladenus* n.g. p. 45
   Intestine not joining esophagus near nerve ring, glands within a basal bulb.....*Neotylenchus* Steiner p. 39

GENUS *NEOTYLENCHUS* STEINER, 1931

Basal bulb of esophagus definitely set off from intestine, the dorsal esophageal gland sometimes enlarged until it forms a lobe extending a short distance back over the intenstine. Lumen of esophagus continuous, not interrupted by a muscular valvular apparatus near the base of the corpus. Spear generally with three definite basal knobs. Ovary prevulvar, outstretched or reflexed. Post-uterine branch absent, except in *Neotylenchus latus*. Spicula, gubernaculum and bursa tylenchoid.

Diagnosis: *Neotylenchinae* possessing a definitely set off basal esophageal bulb and a continuous lumen. Bursa, spicula, and gubernaculum tylenchoid.

Type Species: *Neotylenchus abulbosus* Steiner, 1931.

Comparison of several species of *Neotylenchus* with *Hexatylus viviparus* has demonstrated that these two genera are both valid, being distinguished from each other by the structure of the esophagus, that of *Neotylenchus* possessing a definitely set off basal bulb and a continuous lumen while that of *Hexatylus* is completely fused with the intestine and has a direct break in the lumen near the base of the corpus.

However extreme care must be exercised in identifying these

genera as evidenced by the fact that Dr. Steiner sent the writer specimens of *Hexatylus viviparus* from Germany, which, on casual observation, were thought to be *Neotylenchus abulbosus*. This led to the writer incorrectly to identify *H. viviparus* as *N. abulbosus* in sugar-beets (23).

KEY TO SPECIES OF *NEOTYLENCHUS*

1. Vulva almost terminal.....*obesus* Thorne p. 44
   Vulva well in front of terminus..... 2
2. Posterior uterine branch present.....*latus* Thorne p. 43
   Posterior uterine branch absent..... 3
3. Female tails elongate conoid, a = 8–10..... 4
   Female tails not elongate conoid, a = 15–20..... 5
4. Oöcytes arranged tandem in ovary.....*acutus* n. sp. p. 42
   Oöcytes massed in ovary.....*coprophagus* (Goodey) p. 42
5. Terminus acute 6
   Terminus blunt, rounded..... 7
6. Lip region set off by constriction, male with normal spicula and spear.....*consobrinus* (deMan) p. 41
   Lip region not set off, male with degenerate spicula and without spear.....*abulbosus* Steiner p. 40
7. Bursa enveloping tail, ♀ tail sub cylindroid, very blunt .....*intermedius* (Christie) p. 45
   Bursa not enveloping tail, ♀ tail conoid to small, blunt terminus .....*arcuatus* n. sp. p. 44

NEOTYLENCHUS ABULBOSUS Steiner, 1931

SYNONYM: *Hexatylus abulbosus* (Steiner, 1931) Goodey, 1933

Plate 1, Fig. 1, 1a

♀: 0.76 mm; a = 27; b = 5.5; c = 10.5; V = 67 86.
♂: 0.74 mm; a = 39; b = 11.2; c = 20.

The cylindroid neck, tapering rapidly in its anterior fourth, and the low rounded lip region are well illustrated in Steiner's figure (Plate 1, fig. 1) as is also the form of the esophagus which constitutes one of the most important characters of this genus. Posteriorly the body is shaped much like that of *Hexatylus viviparus* (Plate 4, fig. 9d), the distance from the vulva to the anus being somewhat shorter than the tail length, cuticle marked by four wings. *En face* the head is observed to be divided into eight sectors of practically

equal size. Spear very short, bearing outward curved processes on the distinct basal knobs. Ovary outstretched, sometimes reaching as far as the excretory pore. Male without a spear. Spicula and gubernaculum poorly developed. Bursa crenate, rising slightly in front of the spicula and extending to the terminus.

Neotylenchus abulbosus appears to be most closely related to *N. consobrinus* from which it differs in the rounded lip region, shorter female spear with the outward pointing curved processes of the basal knobs, the absence of a spear in the male and the poorly developed spicula and gubernaculum.

Steiner found this species inhabiting the buds, stems and leaves of strawberry plants affected by "yellows" or "xanthosis" from California and there appears to be little doubt that it is actually endoparasitic, although symptoms have not been accurately defined.

References: 3, 12, 13, 19, 20, 23.

Neotylenchus consobrinus (deMan, 1906) Filipjev, 1936

Synonyms: *Tylenchus consobrinus* deMan, 1906
Hexatylus consobrinus (deMan, 1906) Goodey, 1932

Plate 1, Fig. 2

♀: 0.96 — 1.24 mm; a = 27–36; b = 5.7–7.3; c = 19–23; V — 89–90.
♂: 0.83 — 0.98 mm; a = 36–45; b = 6.3–7.7; c = 17.5–23.

The cap-like lip region is set off by a distinct, though slight, constriction. Two parts of the spear are about equal in length, the shaft bearing very small basal knobs. Esophagus in all respects very similar to that of *Neotylenchus abulbosus*, definitely set off from the intestine. Ovary reflexed a short distance, the oöcytes arranged in single file. Posterior uterine branch absent. Vulva to anus distance slightly greater than length of tail. Spicula and gubernaculum normally developed, tylenchoid. Bursa rising a little anterior to the spicula and enveloping the tail. The above measurements and description from Goodey (14).

Habitat: Sandy soil, Holland, Austria and South Wales.

Transfer of this species to *Neotylenchus* has been made on the basis of its very close resemblance to *N. abulbosus*.

Neotylenchus consobrinus is readily distinguished from *N. abulbosus*, its nearest relative, by the set-off lip region, longer spear with small knobs and the normal, tylenchoid spicula and gubernaculum.

References: 6, 11, 12, 14, 16.

NEOTYLENCHUS ACUTUS Thorne, new species

Plate I, Fig. 3-3c

♀: 0.8 mm; a = 26; b = 4.4; c = 9; V — 60 83.

Body tapering rather uniformly to the rounded lip region which is not set off in any manner, while posteriorly ending in a conoid acute terminus. Transverse striae obscure, more distinct on subcuticle. Wing area a smooth, refractive band about one-fourth as wide as the body. *En face* the head region is found to have the usual eight sectors, the lateral ones much reduced, similar to those of *Neotylenchus latus* (fig. 4). Anterior portion of spear conspicuously set off, about one-half as long as the shaft which bears small but distinct basal knobs. Corpus of esophagus rather cylindrical narrowing to the slender isthmus which passes through the prominent nerve ring. Basal portion of esophagus made up largely of the huge dorsal gland which extends back over the anterior end of the intestine, crowding it to one side, (fig. 3a). Intestine with narrow lumen and dense, thick walls. Vulva a broad, depressed slit. Vagina well sclerotized. Ovary with oöcytes arranged in single file and forming a double flexure (fig. 3c), an unusual thing in this group of nemas. Male unknown and the single female observed contained no spermatozoa.

DIAGNOSIS: *Neotylenchus* most closely related to *N. coprophagus* Goodey, from which it differs in its longer neck, more cylindrical corpus of esophagus, longer isthmus, more posterior position of the excretory pore and the tandem arrangement of oöcytes in the ovary.

HABITAT: Frass of a bark beetle, *Ips lecontei* Swaine, from pinyon pine, *Pinus edulis* Engelmn. near Tabiona, Utah, collected by L. J. Farmer, U. S. Forest Service.

NEOTYLENCHUS COPROPHAGUS (Goodey, 1938) new combination

Plate IX, Fig. 25

♀: 0.88–1.45 mm; a = 18.5–27; b = 6.3–7; c = 8–10.4; V — 82–86.

Body tapering anteriorly until the lip region is only about one-fourth as wide as the neck base, while posteriorly ending in an elongate-conoid pointed tail. Spear 11 – 12 μ long with small but definite knobs. Anterior conical part of spear only half as long as shaft. Esophagus with spindle-shaped corpus two-thirds as wide as neck, narrow short isthmus and lobed basal bulb. Excretory pore opposite

base of lobed bulb. Ovary outstretched, several oöcytes in diameter, probably arranged about a rachis.

This species is closely related to *Neotylenchus acutus*, but differs in shorter, more robust corpus of the esophagus, the more posterior position of the excretory pore and the multiple rows of oocytes which probably are arranged about a rachis.

Transfer of this species to *Neotylenchus* is based on the fact that it obviously is closely related to *N. acutus*, which is without doubt a *Neotylenchus*. Unfortunately the figure for this species was overlooked until the last plate was being assembled, hence its allocation to Plate IX.

HABITAT: Sheep droppings, Winches Farm, St. Albans, England.
REFERENCE: 14.

NEOTYLENCHUS LATUS Thorne, 1935

Plate I, Fig. 4, 4a

♀: 0.7–1.1 mm; a = 17; b = 6.3; c = 18; V = $^{55}85-^{6}$.
♂: 0.8 mm; a = 31; b = 4.7; c = 20; T = 65.

Female attaining its greatest width at about 65 percent. Neck tapering uniformly to the lip region which is not set off in any manner. Wing area marked by four refractive lines. Lateral sectors of head greatly reduced, the amphid apertures distinctly elevated. Spear about 7 μ long with well developed knobs. Esophagus with broadly cylindrical corpus, narrow isthmus and well developed, distinctly set off, basal bulb. Dorsal esophageal gland frequently developed until it rises from the contour of the basal bulb but not usually so conspicuously so as in the specimen figured in the original description.

Oöcytes in several series, perhaps arranged about a narrow rachis. Posterior uterine branch present. Spicula, gubernaculum and bursa tylenchoid, the bursa extending almost to the end of the small but blunt terminus.

Neotylenchus latus is immediately distinguished by the presence of a posterior uterine branch.

HABITAT: Small lesions on roots of shadscale, *Atriplex confertifolia* (Torr. and Frem.) S. Wats., and in the soil surrounding them collected in the desert west of Utah Lake and Richfield, Utah. Also from soil in wheat field near Taylorsville, Utah.

REFERENCE: 22.

Neotylenchus obesus Thorne, 1934

Plate 1, Fig. 5, 5a

♀: 0.7–0.9 mm; a = 10–16; b = 5–6; c = 20–50; V — 95-99.

The obese body varies greatly in form and width. Spear length, 7 μ, with very small knobs. Head rounded with delicate framework in eight almost equal sectors. Esophagus with somewhat spindle-shaped corpus, narrow isthmus and definitely set off basal bulb but the latter generally is obscured by the ovary. Ovary outstretched to opposite nerve ring or even further, with many oöcytes in a circumference, apparently arranged about a rachis. Vulva transverse, sometimes almost terminal. Male unknown.

No other known *Neotylenchus* has such an obese, almost sausage-shaped body and posteriorly located vulva.

Habitat: Eight females from small pit-like lesions on alfalfa crowns, Greely, Colorado.

Reference: 21.

Neotylenchus arcuatus Thorne, new species

Plate 2, Fig. 6–6d

♀: 1.1 mm; a = 15; b = 9; c = 22.5; V — 72 88.
♂: 1.1 mm; a= 39; b = 6.3; c = 17; T — 53.

The obese body of the female usually is found coiled into an open "C". The wing area bears six refractive lines which, on the male occupy about one-fifth of the body width. Lip region divided into the usual eight sectors, the lateral ones which bear the amphids being much reduced. Spear unusually slender, almost devoid of basal knobs. Corpus of esophagus with a slight basal swelling; basal bulb with enlarged glands extending back over its junction with the intestine. Intestine with dense, thick cells in which the nuclei are plainly visible. Ovary sometimes outstretched but generally reflexed a short distance. Posterior uterine branch absent. Eggs slightly longer than body width and half as wide as long. Vulva a broad, transverse slit with elevated labia. Male tail usually bent somewhat dorsad. Testis outstretched. Spicula and gubernaculum tylenchoid. Bursa crenate, extending from a point about opposite the proximal ends of the spicula to near the terminus of the tail.

Diagnosis: *Neotylenchus* with six lines in the wing area, spear

only slightly knobbed, short blunt female tail and a longer, more pointed male tail.

HABITAT: Soil about roots of *Larrea tridentata* (D. C.) Vail., collected near Littlefield, Arizona, by E. W. Davis, U. S. Bureau of Entomology and Plant Quarantine.

NEOTYLENCHUS INTERMEDIUS (Christie, 1938) new combination

SYNONYM: *Hexatylus intermedius* Christie, 1938.

Plate III

♀: 1.46 mm; a = 36; b = 7; c = 21; V — 88-94.
♂: 1.21 mm; a = 35; b = 8; c = 21.

Head rounded, not distinctly set off, dorsal and ventral sectors much reduced. Six minute papillae closely grouped about the oral entrance. Spear 4 to 4.5 μ long with distinct, somewhat diverging basal knobs. Ovary with S-shaped flexure. Other characters as illustrated in Christie's illustration, Plate III.

Neotylenchus intermedius is immediately distinguished by the very small spear and the subcylindroid, blunt female tail.

HABITAT: Decaying citrus fruit, Riverside, California.

Regarding its habits, Dr. Christie states: "*Neotylenchus intermedius* was kept on cultures for about three months. At two-week intervals it was transferred to new cultures on which the fungus *Alternaria citri* previously had been established. It laid eggs freely, built up a moderately large population and appeared to thrive fairly well."

The writer is indebted to Dr. Christie for the loan of his excellent plate.

REFERENCE: 3.

GENUS *DELADENUS* THORNE, NEW GENUS

NEOTYLENCHINAE. Esophagus joining intestine immediately behind nerve ring, the esophageal glands lying free in the body. A chamber-like valvular apparatus sometimes present in the base of the corpus of the esophagus. Vulva located less than 10% from terminus. Ovary prevulvar. Posterior uterine branch absent. Spicula and gubernaculum tylenchoid. Bursa practically enveloping tail.

DIAGNOSIS: *Neotylenchinae* with the above general characters. Especially distinctive because the intestine joins the esophagus immediately behind the nerve ring.

TYPE SPECIES: *Deladenus durus* (Cobb) new combination.

DELADENUS DURUS (Cobb, 1922) new combination

SYNONYM: *Tylenchus durus* Cobb, 1922.

Plate 11, Figs. 7–7i

♀: 1.0 mm; a = 30–50; b = 8–10; c = 25; V = 70 93.
♂: 1.0 mm; a = 50; b = 8.0; c = 24.0; T = 65.

Body rather uniformly cylindrical except at the extremities where it tapers distinctly (figs. 7, 7f). Cuticle marked by transverse striae about 1.5 μ apart. Wing area elevated, consisting of six longitudinal elements. Deirids located in about the latitude of the excretory pore. Phasmids not seen. A single papillae was observed on each of the four rounded lips. Amphid apertures located close to entrance of vestibule. *En face* the head framework is seen to be divided into eight sectors the lateral ones being much reduced. Spear about 8 μ long with well developed basal knobs. Corpus of esophagus with a fusiform basal swelling which contains an ovoid valvular apparatus, which probably is similar in action to that of *Hexatylus viviparus*. The narrow isthmus passes through the conspicuous nerve ring immediately to join the anterior end of the intestine. Joining the dorsal side of the isthmus is the unusually large dorsal esophageal gland which is from four to six times as long as the corresponding body diameter and contains a conspicuous nucleus. The ventrosubmedian glands and their nuclei were not observed. Excretory pore with heavily sclerotized tube which soon is lost to sight in the body tissues but which probably leads to a conspicuous gland nucleus about 10 body widths posterior to the pore. Intestinal lumen very narrow, beginning to zig-zag almost immediately behind the esophagus and finally becoming twisted and convoluted in a most amazing manner (fig. 7g). Cells of intestine small, the nuclei lying between the bends of the lumen. In some specimens the lumen was broad at is junction with the rectum (fig. 7h) in others it remained narrow (fig. 7f).

Vulva a broad, transverse slit from which the heavily sclerotized vagina leads in and forward to the muscular uterus. Many ova may be present at one time. At first the oöcytes are arranged in single file but, as growth takes place, the ovary is distended and the oöcytes lie in four rows. No rachis was observed. Male tail bearing a bursa which rises a little in front of the spicula and envelopes all but the extreme tip of the tail. Spicula tylenchoid, resting on a simple, curved, trough-like gubernaculum. Testis outstretched.

DIAGNOSIS: *Deladenus* with an avoid valvular apparatus in the

corpus of the esophagus and greatly developed dorsal esophageal gland. Amphids lying deep in the lateral labial axils. Lumen of intestine greatly convoluted. Wing area elevated and divided into six elements.

HABITAT: Described by Cobb from galls of chestnut oak, *Quercus prinus* L., near Lebanon Church Postoffice, Virginia. Decaying fungus, *Pleurota* sp., and under dead bark of cottonwood, *Populus fremonti*, S. Wats., on which the fungus was growing. Collected by C. W. McBeth near Payson, Utah. Also from soil about alfalfa crowns near Manti and Murray, Utah, and Medford, Oregon. The only two males found were in the Manti collection. The specimens from soil generally had slightly longer necks and the excretory pore was somewhat more posteriad.

REFERENCE: 4a.

DELADENUS OBESUS Thorne, new species

Plate IV, Figs. 8 – 8c

♀: 1.0–1.5 mm; a = 16–22; b = ?; c = 30; V – 85 93.

Distinct striae near the lip region are about 1.5 μ wide but these become obscure on the neck and body, sometimes being visible only on the subcuticle. Phasmids and derids not observed. A definite wing area is not visible but in cross section there is a sclerotized band about one-fourth as wide as the body which is not set off in any manner and this may be marked by eight or ten excessively minute striae. Excretory pore, duct and gland not seen. *En face* the head is seen to be divided into 8 sectors the lateral ones which bear the amphids being much reduced. Vestibule a refractive tube. Corpus of esophagus elongate, spindle shaped. Lumen of esophagus unbroken, joining with the broad lumen of the intestine close behind the nerve ring. Esophageal glands grouped about the anterior end of the intestine in flattened lobes. Lumen of intestine at first broad, then narrowed and convoluted, but not so extremely bent as in *Deladenus durus*. A short, postrectal sac was present in one of the two specimens examined. Vulva a broad transverse slit with prominent labia. Vagina extending in and then forward to the conspicuously cellular oviduct. Eggs about half as wide as body and four to six times as long as wide. Great numbers of oöcytes are arranged in eight or ten lines about a prominent rachis. In old females the ovary may be outstretched past the nerve ring or reflexed a short distance, the terminus lying dorsad in the body while the major portion of the ovary is ventrad. Male unknown.

Diagnosis: *Deladenus*-like form without an ovoid valvular apparatus in the corpus of the esophagus. Esophageal glands lobe-like, grouped about the anterior end of the intestine.. Wing area an obscure band.

Placing this species in *Deladenus* is a questionable procedure because it lacks the characteristic ovoid valvular apparatus in the corpus of the esophagus.

Habitat: Frass of unidentified beetles under bark of dead white fir, *Abies concolor* Lindl., near Wolf Creek Summit, South Fork of Provo River, Utah.

GENUS *HEXATYLUS* GOODEY, 1926

Diagnosis Emended: *Neotylenchinae*. Esophagus base fused with intestine. Lumen of esophagus with a distinct break near the base of the corpus where the lumen becomes much wider, the walls heavier and a muscular valvular apparatus apparently is present. Pharynx slightly sclerotized, forming several minute guiding rings for the spear. Spear with three well-developed basal knobs, each of which is somewhat duplex. The outer surface of these basal knobs is unusually refractive and conspicuous. *En face* the octagonal lip region is observed to be divided into 12 approximately equal sectors with four smaller triangular sectors at the submedial angles through which the circlet of four papillae emerge. (Plate IV, Fig 9). The basal framework of the head retains the octagonal pattern of the genus (Fig. 9a), although in some specimens there is a tendency for the 16-sector pattern seen at the surface to continue back to the basal framework.

Type Species: *Hexatylus viviparus* Goodey, 1926.

The above emended diagnosis is based on specimens kindly sent to the writer by Dr. Goodey from Middlesex, England. Dr. Steiner also forwarded specimens from potatoes imported from Germany which proved to be identical to those from England. Specimens collected by the writer from Utah and California were also compared, lateral and *en face* examinations being made of specimens from all four collections.

KEY TO SPECIES OF *HEXATYLUS*

1. ♀ length near 3.0 mm, tail ventrally arcuate.....
.....*fungorum* (Bütschli) p. 49
♀ length 1.5 mm or less, tail straight..*viviparus* Goodey p. 49

Hexatylus viviparus Goodey, 1926

Plate IV, Figs. 9–9d

♀: 1.0–1.5 mm; a = 15–35; b = 5–7; c = 17–20; V = ^{70}89.

With characters of the genus. The great variation in width is found between females which have reached their normal length but have not begun egg production, and those approaching senility. Senile specimens frequently somewhat shorter than the younger forms associated with them. Phasmids and deirids not observed. Wing area marked by four refractive lines, the two outer ones being more prominent. The tissues of the basal portion of the esophagus are somewhat less dense in texture than those of the intestine to which they are fused. This basal portion encloses a number of nuclei, some of which appear identical to those of the intestine while others are probably the nuclei of the esophageal glands. Nuclei of intestinal cells less than one body width apart. Intestine probably four cells to a circumference but this point was not definitely determined as cell walls were not visible.

Ovary of adults reaching as far forward as the nerve ring, the anterior portion made up of several hundred massed oöcytes which, as they increase in size, are observed to be grouped about a prominent rachis. Only the anterior half of the ovary is occupied by the oöcytes, the remainder being a long tube in which the ova develop. A short oviduct leads to a pouch-like uterus. Vulva a broad transverse slit.

Habitat: Described by Goodey from a diseased potato tuber and also decaying gladiolus corms. Cultures from the corm transferred to 2% malt-extract agar gave a good growth of fungus mycelium on which these nematodes thrived and reproduced in great numbers. Goodey therefore regards the species as saprophagous rather than an obligate parasite.

References: 3, 6, 9, 10, 12, 13, 19, 20.

Hexatylus fungorum (Bütschli, 1873) Goodey, 1932

Synonyms: *Tylenchus fungorum* Bütschli, 1873.
Neotylenchus fungorum (Bütschli, 1873) Filipjex, 1936.

Plate IV, Fig. 10, 10a

♀: 3.0 mm; a = 21; b = ?; c = 30; V = 93.8.
♂: 1.6–2.0 mm; a = ?; b = ?; c = 15.

Spear very small, 0.0129 mm in full-grown female. Esophagus indefinite but Bütschli shows a cylindrical corpus narrowing to a slender isthmus which apparently joins directly to the intestine as it does in *Hexatylus viviparus*. Ovary outstretched, very broad anteriorly as if the oöcytes were arranged about a rachis. Several of the small ova are arranged in single file in the long oviduct. Vulva a depressed slit. Spicula and gubernaculum of a most extraordinary form. Bursa three times as long as the tail, completely enveloping the terminus.

Habitat: *Decaying fungus*, Germany.

Goodey's designation of this species to *Hexatylus* perhaps brings it into the correct subfamily but the writer feels that it probably belongs to an unknown genus. However, this question will not be solved until specimens are again collected.

References: 1, 3, 6, 11.

Iotonchium imperfectum (Bütschli, 1876) Cobb, 1920

Synonym: *Tylenchus imperfectus* Bütschli, 1876

Plate IV, Figs. 11 – 11b

♀: 1.8 mm; a = 24; b = 7.2; c = 12.9; V = 88.

Head truncated, set off by expansion. Spear of female 8 μ long while in the male it is reduced to a mere point. Intestine clear and transparent. Gonads reaching to near base of esophagus. Eggs slightly longer than body width. Males smaller than females. Spicula yellow or brown in color, very angular. Gubernaculum absent. Bursa rising one body width anterior to spicula and completely encompassing the tail.

Bütschli states that in general structure this species resembles *Hexatylus fungorum* (Bütschli, 1873) so we are probably safe in assuming that it has a *Hexatylus*-like esophagus.

Habitat: Decaying mushrooms, Germany.

References: 2, 4, 6.

Paurodontinae Thorne, new subfamily

Tylenchidae. Basal esophageal bulb possessing a stem-like extension. Intestine often enveloping part, or even all, of the basal esophageal bulb. Ovary prevulvar, outstretched. Posterior uterine branch absent. Spicula tylenchoid. Bursa enveloping tail. Body generally very dense in texture and details frequently difficult to observe.

Diagnosis: The subfamily *Paurodontinae* is immediately differentiated from all other *Tylenchidae* by the stem-like extension of the esophageal bulb.

Type Genus: *Paurodontus* Thorne, new genus.

KEY TO GENERA OF *PAURODONTINAE*

Spear knobs symmetrical.....*Paurodontus* n. g. p. 51
Spear knobs asymmetrical, the ventrosubmedian much larger than the dorsal.....*Stictylus* n. g. p. 54

GENUS *PAURODONTUS* THORNE, NEW GENUS

Paurodontinae. Characters of the subfamily. Knobs of spear symmetrical, or nearly so. Tails of both sexes acute or subacute. Bursa, where known, not enveloping entire tail.

Diagnosis: *Paurodontus* is immediately distinguished from *Stictylus,* its only known relative, by the symmetrical basal knobs of the spear and the pointed tails of both sexes.

Type Species: *Paurodontus gracilis,* n. sp.

KEY TO SPECIES OF *PAURODONTUS*

1. Length about 0.7 mm.....*gracilis* n. sp. p. 51
   Length about 0.4 mm..... 2
2. Terminus subacute, tail somewhat arcuate..*densus* n. sp. p. 52
   Terminus acute, tail rather straight..... 3
3. Head about half as wide as neck base....*apiticus* n. sp. p. 53
   Head almost as wide as neck base.....*niger* n. sp. p. 54

Paurodontus gracilis Thorne, new species

Plate V, Figs. 12–12d

♀: 0.74 mm; a = 31; b = 7.2; c = 7.2; V = $^{54}76^{3}$.
♂: 0.65 mm; a = 35; b = 5.5; c = 6.5; T = 58.

Cuticle marked by transverse striae, which are about 1.3 μ apart at their widest points. Wing areas marked by four equally spaced, refractive lines occupying about one-third the body width. Deirids and phasmids not seen. Lip region low, rounded. Amphidial apertures located on minute elevations of the lateral lips. Spear slightly longer than width of head with distinct basal knobs. Corpus of esophagus cylindrical, narrowing to the slender isthmus which passes through the conspicuous nerve ring and then enlarges to form the

basal bulb. This bulb bears an elongated tubular valvular apparatus by which it is connected with the intestine. A peculiar chamber, which apparently is formed by the extended walls of the intestine, surrounds the bulb. Nucleus of the dorsal esophageal gland easily seen but the two submedian gland nuclei are very obscure. Intestine made up of large thick cells, each with a distinct nucleus.

Anterior ovary outstretched, the ova arranged in single file. Anterior portion of oviduct forming a spermatheca. Vulva a transverse slit. Posterior uterine branch rudimentary, about as long as width of body. Spicula tylenchoid, arcuate. Gubernaculum thin, curver, trough-like. Bursa slightly crenate, two and one-half times as long as anal body diameter. Testis outstretched.

Diagnosis: *Paurodontus* with the above measurements and general description. Distinctive because of the slender, acutely, pointed tail, four wings and a rudimentary posterior uterine branch.

Habitat: Soil about cotton roots, collected by C. W. McBeth, Tifton, Georgia.

Paurodontus densus Thorne, new species

Plate V, Figs. 13–13c

♀: 0.4 mm; a = 25; b = 5.7; c = 12; V — 55 82.

Anteriorly the body tapers gradually so that the width of the head is about one-half that of the base of the neck. Posteriorly there is a rapid tapering from the vulva to the subacute terminus of the slightly arcuate tail. Wing area one-third as wide as body and appearing as six bright lines, the two outer ones more conspicuous. On the neck and tail there is a reduction in numbers of the wing lines until they practically disappear at the extremities. Phasmids not seen but a very indistinct deirid was observed on one specimen, located in the middle of the wing area about opposite the esophageal bulb. *En face* the head is found to be composed of six sectors, the two lateral ones which bear the amphids being much narrower than the four submedian on which the papillae are located. Vestibule a sclerotized tube. Spear strongly knobbed but the knobs and the shaft are generally very difficult to see on glycerin-mounted specimens because of their refractive index. Esophagus beginning as a rather uniform tube about one-third as wide as the neck, narrowing through the nerve ring and then expanding to form the spindle-shaped bulb with its long posterior extension (fig. 13a). Esophageal gland nuclei within the bulb, apparently three in number but nothing was determined concerning their outlets.

Excretory tube strongly sclerotized. Intestine almost filling the body cavity, without distinct cell arrangement. A peculiar structure surrounds the extension of the esophageal bulb, resembling the tissues of the intestine.

Vulva a broad, depressed slit. Vagina extending inward to join the thin-walled uterus. Oviduct elongated, cellular, but apparently not bearing a special branch like that of *Paurodontus apiticus*. Ovary composed of very small oöcytes arranged in single file. In the distal end of the oviduct of some specimens there were numbers of bodies which appeared to be spermatozoa but no males were collected.

Diagnosis: *Paurodontus* with the above measurements and general characters. Most closely related to *P. niger* from which it differs in the stronger spear, slightly arcuate tail with subacute terminus and the proportionately greater distance between the vulva and anus.

Habitat: Soil about the roots of date palms, McMillian gardens, Indio, California.

Paurodontus apiticus Thorne, new species

Plate V, Fig. 14–14d

♀: 0.42–0.7 mm; a—16-22; b—4.0-7.0; c—8.2-12.0; V—^{45} 80-^{56} 85.

As the above formulae show there is a great diversity in size and body proportions in this species. The obese body tapers anteriorly until the lip region is only about two-fifths as wide as the base of the neck while posteriorly it diminishes rapidly from the vulva to the spicate terminus. Usually the body becomes almost straight when the nema is killed by gradual heat. Transverse striae are easily visible throughout the length of the body. Wings very obscure except on the neck. Phasmids and deirids not seen. Head, *en face*, in 6 sectors, the four submedian ones bearing papillae and the two narrow, protruding, lateral ones bearing the amphids. Vestibule a sclerotized, conoid tapering tube. Spear about as long as width of lip region with distinct, small knobs. Esophagus a somewhat irregular tube, narrowing as it passes through the nerve ring then expanding to the spindle-shaped bulb which bears a long posterior extension reaching back to the intestine. The three esophageal gland nuclei lie within the bulb. Excretory pore usually about opposite base of bulb. Intestine thin walled, its lumen broad. In many specimens the tissues surrounding the bulb extension looked very much like those of the intestine and it may be possible that they form an anterior chamber.

The single out-stretched ovary rarely reaches to the base of the

neck and is made up of oöcytes arranged in single file. Vulva a broad transverse slit from which the vagina extends inward a short distance to join the thin-walled uterus. Oviduct composed of many protruding cells giving it somewhat the appearance of a bunch of grapes. Attached to the anterior end of the oviduct is a short branch which may function as a spermatheca.

Diagnosis: *Paurodontus* with the above measurements and general description. Distinctive because of the tapering neck, straight, pointed tail, and the short branch of the oviduct.

Habitat: Soil about the roots of *Larrea tridentata* (D. C.) Vail., Littlefield, Arizona, U. S. A. Also from soil around roots of barley, Yuma Experiment Station, Bard, California; and cotton, Arvin, California.

Paurodontus niger Thorne, new species

Plate VI, Fig. 15, 15a

♀: 0.4 mm; a = 24; b = 6.3; c = 8; V — $^{40}80^{2}$.

Body tissues even more dense than is usual in this genus, making observation of the organs very difficult. Neck tapering but little to the rounded lip region. Tail conoid to the pointed terminus. Wing area marked by six lines occupying about one-fourth the body width. Lips apparently arranged like those of *Paurodontus densus* (fig. 13). Spear as long as head width, slender and bearing well-developed, symmetrical basal knobs. Esophagus with an irregular cylindrical corpus, narrow isthmus and greatly variable basal bulb which bears an elongated valvular apparatus attaching it to the intestine. Lumen of esophagus very obscure. Intestine with dense, irregular sized granules.

Ovary outstretched, the oöcytes arranged in single file. Eggs fill the body cavity and are about three times as long as wide. Oviduct without a special branching spermatheca as in *Paurodontus apiticus*. Vulva a depressed transverse slit.

Diagnosis: *Paurodontus* with the above measurements and general characters. Most closely related to *P. apiticus* from which it differs in the relatively broader lip region, conspicuous wings and absence of an oviduct branch.

Habitat: Soil about roots of shadscale, *Atriplex confertifolia* (Torr. & Frem.) S. Wats. collected west of Utah Lake, Utah, above the abandoned Mosida irrigation project.

GENUS *STICTYLUS* THORNE, NEW GENUS

Paurodontinae. Characters of the subfamily. Spear with asym-

metrical knobs, the ventrosubmedian ones being much larger than the dorsal one. Tail blunt and rounded. Bursa, where known, enveloping almost the entire tail.

Diagnosis: *Stictylus* is immediately differentiated from *Paurodontus*, its only known relative, by the asymmetrical spear knobs, and blunt tail.

Type Species: *Stictylus asmmmetricus* Thorne, new species.

KEY TO SPECIES OF *STICTYLUS*

1. Vulva a depressed slit.....*obtusus* n. sp. p. 55
   Vulva with protuberant labia.....*asymmetricus* n. sp. p. 55

Stictylus asymmetricus Thorne, new species

Plate VI, Figs. 16–16f

♀: 0.8 mm; a = 22; b = 5.1; c = 27; V 70 90.
♂: 0.8 mm; a = 27; b = 5.7; c = 23; T — 65.

The obese body of the female generally assumes an arcuate form. The four lines of the wing area occupy from one-fourth to one-third of the body width. Lip region low, rounded, not set off. The submedian knobs of the spear are much larger than the dorsal one and at first the lumen of the esophagus follows ventrad against them. The outlet of the dorsal esophageal gland appears to empty directly into the base of the spear. Corpus of esophagus generally with a spindle-shaped swelling. Basal extension of the basal bulb variable in length (fig. 16b, 16d). Intestinal cells filled with dense, coarse granules.

Ovary outstretched in young females but usually reflexed a short distance in older ones with an occasional specimen in which it is doubly flexed. Oviduct cellular. Vulva a broad transverse slit with elevated labia. Spicula and gubernaculum tylenchoid. Bursa enveloping the tail almost to the terminus.

Diagnosis: *Stictylus* with the above measurements and general description. Distinguished from *S. obtusus* by the form of the basal esophagus bulb, the shorter tail, and elevated labia of the vulva.

Habitat: Soil about roots of desert plants near the U. S. Field Station, Sacaton, Arizona.

Stictylus obtusus Thorne, new species

Plate VI, Fig. 17, 17a

♀: 1.0 mm; a = 25; b = 6.4; c = 18; V — 66 90.

Cuticle with fine transverse striae. Neck tapering uniformly to the low, rounded lip region. Posteriorly the body tapers to the blunt, rounded tail which is about twice as long as the anal body diameter. The spear is slightly longer than the width of the lip region and is strongly knobbed, the two ventro-submedian knobs being much the larger. Corpus of esophagus with an elongated, spindle-shaped swelling slightly less than one-third as wide as the body. Isthmus slender, surrounded by a very distinct nerve ring. Basal bulb of esophagus ovate, its lumen triquetrous. Basal extension of bulb bluntly-conoid. Intestine with thin walls and scattering, variable-sized granules. At first it is three-fifths as wide as the body but almost immediately is crowded to one side by the ovary. Excretory pore opposite base of esophagus.

Ovary reflexed half way back to vulva with oöcytes arranged in single file. Uterus broad, thin-walled. Vagina extending about one-third the distance across the body, then turned almost at right angles to form an elongated, somewhat funnel-shaped portion connection with the uterus. Vulva a broad depressed slit.

Diagnosis: *Stictylus* with the above measurements and general description. Distinguished from its closets relative, *S. asymmetricus*, by the longer female tail, depressed labia of vulva, long reflexed portion of ovary, and triquetious lumen of the basal esophageal bulb.

Description and figures from notes and sketches made of a single specimen collected May 22, 1923, from soil about the roots of sugar-beets near Lewiston, Utah. Due to the writer's inexperience at that time it may be possible that the recording of a triquetrous, valvular lumen in the esophageal bulb was an error.

Nothotylenchinae Thorne, new subfamily

Tylenchidae. In general form and appearance these nematodes closely resemble those belonging to the genera *Tylenchus* and *Dity-lenchus*. Corpus of esophagus either cylindroid or bearing a fusiform basal swelling without a valvular apparatus. Head framework divided into six sectors. Ovary prevulvar, posterior uterine branch always present. Spicula and gubernaculum tylenchoid.

Diagnosis: *Tylenchidae* without a valvular median esophageal bulb. Distinguished from *Neotylenchinae* by the presence of only six sectors is the cephalic framework. From *Paurodontinae* it is immediately differentiated by the absence of a posterior extension of the basal esophageal bulb.

Type Genus: *Nothotylenchus* Thorne, new genus.

KEY TO GENERA OF *NOTHOTYLENCHINAE*

1. Cuticle abnormally thick and deeply striated. *Thada* n. g. p. 62
   Cuticle not abnormally thick, finely striated..... 2
2. Spear with tylenchoid basal knobs. *Nothotylenchus* n. g. p. 57
   Spear with flange-like basal projections. *Boleodorus* n.g. p. 59

Nothotylenchus Thorne, new genus

Nothotylenchinae: Cuticle thin, marked by fine transverse striae which are interrupted on the lateral fields by a wing area marked by four or more bright lines. Cephalic framework in six sectors. Spear with rounded basal knobs. Corpus of esophagus cylindrical, with or without a fusiform valveless bulb. Basal bulb of esophagus distinctly set off from intestine, sometimes slightly lobed. Anterior ovary outstretched, the oöcytes arranged in single file. Rudimentary posterior uterine branch present. Spicula and gubernaculum tylenchoid. Bursa rising slightly anterior to spicula and extending to near the middle of the tail.

Diagnosis: *Nothotylenchinae* with the above general characters. Distinguished from *Thada* by the thin, finely-striated cuticle and from *Boleodorus* by the rounded basal knobs of the spear.

Type Species: *Nothotylenchus acris* Thorne, new species.

To the uninitiated this group of names presents a puzzling problem, for unless very careful examination is made under the highest powers of the microscope, they may easily be mistaken for *Ditylenchus dipsaci* (Kuhn) Filipjev or *D. intermedius* (deMan) Filipjev, especially since they are so frequently associated with alfalfa crowns where these two species often are found.

KEY TO SPECIES OF *NOTHOLYLENCHUS*

1. Basal esophageal bulb elongate-cylindrical..... .....*cylindricollis* n. sp. p. 59
   Basa esophageal bulb tapering..... 2
2. Terminus acute, wings 4.....*acris* n. sp. p. 57
   Terminus rounded, wings 6.....*affinis* n. sp. p. 58

Nothotylenchus acris Thorne, new species

Plate VII, Figs. 18–18c

♀: 0.9 mm; a = 33; b = 6.2; c = 15.5; V — 40 80.
♂: 0.7 mm; a = 35; b = 6.5; c = 9.5; T — 48.

Body tapering anteriorly until the lip region is only about one-fourth as wide as the neck base. The conoid tail ends in an abruptly conoid, pointed terminus. Wing area marked by four lines which occupy about one-fifth of the body width. Deirids very obscure, located near the base of the neck. Phasmids not seen. Spear slender, the apical portion occupying only about one-third of its length. Basal knobs of spear small, distinct. Corpus of esophagus with a fusiform valveless bulb. Isthmus long, slender, encircled by the conspicuous nerve ring. Lumen of esophagus exceedingly fine (exaggerated in fig. 18), passing through the ventral portion of the basal bulb. Dorsal esophageal gland nucleus large and conspicuous; submedian gland nuclei very small, often invisible. Basal portion of esophageal bulb slightly lobed, extending back over the conoid, valvular apparatus connecting it to the intestine. Intestine with thick walls and narrow lumen. Ovary outstretched with oöcytes arranged in single file. Anterior portion of oviduct forming a spermatheca. Posterior uterine branch two to three times as long as body width. Spicula practically identical to those of nemas of the genus *Tylenchus*. Gubernaculum thin, trough-like. Bursa beginning about opposite the proximal ends of the spicula and extending slightly past the middle of the tail. Testis outstretched.

Diagnosis: *Nothotylenchus* with wing area marked by four lines and tail ending with an abruptly conoid, pointed terminus.

Habitat: Soil about alfalfa crowns, Medford, Oregon, red clover roots, Redmond, Oregon, and sugar-beets, Arvin, California.

Nothotylenchus affinis Thorne, new species

Plate VII, Figs. 19–19c

♀: 0.65 mm; a = 33; b = 5; c = 9; V — 41 71.
♂: 0.64 mm; a = 32; b = 6.4; c = 11; T — 70.

Neck tapering rather uniformly throughout its length until the lip region is about one-half as wide as the neck base. Posteriorly the tails of both sexes taper uniformly to the small rounded terminus. Distance from vulva to anus approximately the same as the tail length. Wing area marked by six refractive lines, the two outer ones being the most prominent. Spear averaging 8 μ long with well developed basal knobs. Esophagus very similar to that figured for *Nothotylenchus acris* (fig. 18c). Ovary outstretched. Posterior uterine branch shorter than the body width. Spicula arcuate, about 15 μ long. Gubernaculum thin, trough-like. Bursa rising about opposite the anterior end of the

spicula and extending to the middle of the tail.

DIAGNOSIS: *Nothotylenchinae* with uniformly tapering neck, six lines in wing area, small rounded tail terminus, very short posterior uterine branch and distance vulva to anus equal to tail length.

HABITAT: Dying alfalfa crowns near Manti, Utah.

NOTHOTYLENCHUS CYLINDRICOLLIS Thorne, new species

Plate VII, Fig. 20, 20a

♀Y: 0.7 mm; a = 34; b = 5; c = 17; V — 53 90.
♂: 0.9 mm; a = 40; b = 5; c = 12; T — 40.

Neck cylindrical except in the anterior third where it becomes convex-conoid and tapers rapidly to the lip region which is only about one-fourth as wide as the neck base. Tails of both sexes tapering uniformly to a pointed terminus. Vulva to anus distance only about half of tail length. Wing area one-third as wide as body, marked by four refractive lines. Spear about 7 μ long with small basal knobs, the width at the knobs being only one-eighth of the head width. Corpus of esophagus cylindroid without any indication of a median swelling or valve. Isthmus about as long as neck width. Basal esophageal bulb cylindroid, three times as long as neck width. Ovary outstretched. Vagina extending in and forward from the depressed transverse vulva. Posterior uterine branch about as long as the body width. Spicula 20 μ long, slightly arcuate. Gubernaculum thin, trough-like. Bursa rising a little anterior to spicula and extending to middle of tail.

DIAGNOSIS: *Nothotylenchus* with basal two-thirds of neck nearly cylindrical, distance vulva to anus only half the tail length, and cylindroid corpus and basal bulb of the esophagus.

HABITAT: Soil and organic debris at base of *Ananas* sp., Paraguay.

GENUS *BOLEODORUS* THORNE, NEW GENUS

NOTHOTYLENCHINAE: Cuticle thin, marked by fine transverse striae about 1 μ apart at tehih widest points. A full set of 16 cephalic papillae probably present. Cephalic framework in six sectors. Spears of known species about 12 μ long with three prominent basal flanges. Corpus of esophagus with fusiform, valveless basal swelling. Basal bulb of esophagus distinctly set off from intestine, not lobed, joined with intestine by a well-developed valvular apparatus. Vulva a transverse slit. Ovary outstretched. Oviduct made up of large cells some of which may form a pouch-like spermatheca. Posterior uterine

branch less than half as long as body width. Spicula and gubernaculum tylenchoid. Bursa only about twice as long as body width.

Diagnosis: *Nothotylenchinae* with long (12 μ) spears bearing basal flanges instead of rounded knobs.

Type Species: *Boleodorus thylactus* Thorne, new species.

Boleodorus thylactus Thorne, new species

Plate VIII, Fig. 21–21h

♀: 0.6 mm; a = 31; b = 5.5; c = 8.0; V = $^{36}61^{1.0}$.
♂: 0.5 mm; a = 33; b = 5.0; c = 7.2; T =

Body arcuate when relaxed by gradual heat, the female tail almost always somewhat hooked, male tail straighter. Bodies of fixed specimens always twisted until the head and tail are seen from a slightly submedian view. Cuticle and subcuticle marked by transverse striae which are about 1.0 μ apart near the middle of the body. Wing area a refractive band about one-fifth the body width, bordered by two conspicuous bright lines and bearing two more very faint lines which divide the area into three equal spaces. Deirids slightly posterior to base of neck, phasmids about one body width posterior to anus. Excretory pore with heavily sclerotized tube. Neck tapering gradually to the convex-conoid, unstriated lip region which is much more transparent than the adjacent head. *En face* the lip region is seen to be divided into six sectors, the two lateral ones being very much reduced. The basal portion of the libial framework is obscurely hexagonal.

A study of specimens stained *intra vitam* with neutral red and gentian blue show that apparently there are sixteen cephalic papillae. Six of these are grouped closely about the entrance to the vestibule and are exceedingly difficult to observe; four distinct ones are located near the margins of the submedial lips and six, generally very obscure, are found at the base of the lip region. Of the six at the base of the lip region, the two laterals are somewhat more distinct and located slightly more posteriod than the submedian ones. Amphid apertures minute, oval, located one-third the way back on the lip region. Amphidial tubes and pouches especially conspicuous when stained by neutral red (fig. 21c).

Vestibule strongly sclerotized. Spear 12 μ long, the distal portion being about 4 μ long. Basal knobs of spear distinctly flange-like and from a lateral view the spear frequently has a trifurcate appearance. Outlet of dorsal esophageal gland near base of spear. Corpus of

esophagus at first tubular then expanding to form an elongate-fusiform bulb in which the reservoirs and openings of the two submedian esophageal glands are located. Isthmus slender, gradually expanding to form the basal bulb which contains the large dorsal gland nucleus. The submedian gland nuclei were not definitely observed. A small valvular apparatus connects the esophageal lumen with the thick-walled intestine. Intestine two cells in circumference, containing scattered, refractive granules. Rectum slightly longer than anal body diameter, ending in a distinct anus.

Vulva a transverse slit. Vagina extending half way across body. Anterior ovary outstretched, the oöcytes arranged in single file. Posterior uterine branch rudimentary, half as long as body width. Oviduct composed of columnar cells. Just after fertiization the spermatoza are found in the lumen of the oviduct but soon the fifth dorsal cell from the uterus enlarges to form a sac-like spermatheca, hence the specific name *thylactus* (pouch). Testis single, outstretched. Spicula slender, arcuate, slightly cephalated. Gubernaculum a thin curved trough. Bursa about twice as long as anal body diameter with crenate border.

Diagnosis: *Boleodorus* with ventrally arcuate body and hooked female tail tapering uniformly to an acute terminus.

Habitat: Cultivated soil, especially about alfalfa crowns, Salt Lake, Utah and San Pete Counties of Utah, Ft. Collins and Grand Junction, Colorado, Twin Falls and Caldwell, Idaho, Fallon, Nevada, and Albion, California.

Boleodorus clavicaudatus Thorne, new species

Plate VIII, Fig. 22–22b

♀: 0.7 mm; a = 31; b = 5.7; c = 8.5; V = ^{30}60.

Cuticle marked by fine transverse striae which are about 1 μ apart at their widest points. Wing area about one-third as wide as the body, bordered by two bright refractive lines with two less prominent ones between them. Body tapering rather uniformly until the lip region is only about one-third as wide as the neck base. Tail uniformly conoid to the slightly clavate terminus. Spear 13 μ long with broad basal flanges. Details of esophagus as illustrated (fig. 22b), the basal bulb being only a little longer than the neck width. Excretory pore about opposite base of esophagus.

Ovary outstretched, very short in the five young females examined. Spermatoza were present in the oviduct of two specimens and it ap-

peared as if a spermatheca was forming as in *B. thylactus*. Vulva a depressed slit. Posterior uterine branch similar to that of *B. thylactus* (fig. 21g).

Diagnosis: *Boleodorus* with rather straight body and elongated clavate tail which readily distinguishes it from *B. thylactus*.

Habitat: Soil about alfalfa crowns, Yuma Experiment Station, Bard, California.

GENUS *THADA* THORNE, NEW GENUS

Nothotylenchinae. Very small nemas with abnormally thick cuticle marked by deep, transverse striae and sometimes also by similar longitudinal ones. Cephalic framework in six sectors. Spear with or without basal knobs. Esophagus with plain cylindroid corpus and slender isthmus. Esophageal gland nuclei within the definitely set off elongate basal bulb. A cap-like valvular apparatus occupies the anterior end of the intestine, connecting it with the esophagus. Ovary outstretched, the oöcytes arranged in single file. Posterior uterine branch shorter than body width. Spicula arcuate, cephalated by avoid expansion. Gubernaculum thin, trough-like. Bursa thick, without supporting ribs, extending an equal distance before and behind the anus.

Diagnosis: *Nothotylenchinae* of small size with unusual thick, deeply striated cuticle, cap-like valvular apparatus joining intestine and esophagus and ovate cephalation of the spicula.

Type Species: *Thada striata* Thorne, n. sp.

The name *Thada* has no significant meaning, merely being an arbitrary combination of letters.

KEY TO SPECIES OF *THADA*

1. Cuticle marked by only transverse striae. . . . *striata* n. sp. p. 62
   Cuticle marked by both transverse and longitudinal striae
   . . . . . *cancellata* n. sp. p. 63

Thada striata Thorne, new species

Plate IX, Fig. 23–23e

♀: 0.65 mm; a = 30; b = 6.0; c = 9.0; V = $^{37}71^{2}$.
♂: 0.52 mm; a = 26; b = 5.2; c = 8.0; T = 48.

Body practically cylindrical between vulva and base of neck; anteriorly tapering rapidly to the convex-conoid head until the lip region is about one-fourth as wide as the base of the neck. Posteriorly the body tapers rather uniformly to the conoid, bluntly rounded, tail. On

many specimens there was a slight enlargement or swelling of the tail near its middle and in some instances this condition was rather prominent and may indicate that the deformity is due to some disease. The thick cuticle is cut by deep transverse striae which are coarser on the female than on the male. The wing area is marked by four conspicuous refractive wings which at midbody occupy from one-third to three-fifths the body width. Anteriorly the wing area ends in two rows of plates (Fig. 23c). On the tail the wings vary greatly in their arrangement from the symmetrical form (fig. 23d) to the somewhat spiral (fig. 23e). The latter type is found on the tails which bear swellings.

There are six lips, the lateral ones being distinctly smaller than the submedian. Details of the basal knobs of the slender spear are difficult to observe. The esophagus and its valve are practically identical to those of *Thada cancellata* (fig. 24e). The narrow lumen of the intestine is about as wide as the thickness of the body cuticle.

Vulva a broad transverse slit. Oviduct forming a spermatheca in its anterior portion. Ovary outstretched, the oöcytes arranged in single file. Posterior uterine branch shorter than body diameter.

Spicules arcuate, cephalated in a typical form (fig. 23b). Gubernaculum a thin curved plate. Bursa very thick, without crenate borders except near body. The single testis is reflexed a distance equal to one or two body widths.

Diagnosis: *Thada* with transversely striated cuticle, not marked by longitudinal striae as in *T. cancellata*.

Type Habitat: Desert soil about roots of shadscale, *Atriplex confertifolia* (Torr. & Frem.) S. Wats., collected west of Utah Lake, Utah, above the abandoned Mosida irrigation project. Also from alfalfa crowns, Brown's Ranch, Skull Valley, Utah.

Thada cancellata Thorne, new species

Plate IX, Fig. 24 – 24e

♀: 0.52 mm; a = 25; b = 5.4; c = 8; V = $^{20}66^{2}$.

Body practically straight when relaxed by gradual heat. Cuticle marked by 155 to 175 deep transverse striae. At midbody there are 16 longitudinal striae, the number decresing toward the extremities. There are four prominent wings which alter on the neck and tail as shown in figs. 24a, b. Deirids and excretory pore prominent, located opposite the basal esophageal bulb. Phasmids not seen. The numbers of lips and papillae on the low rounded head could not be determined

from a lateral view but are probably the same as in *Thada striata*. Vestibule and pharynx sclerotized. Spear exceedingly slender, its basal portion obscured by the muscle attachments until it was not possible to determine if basal knobs were present. Esophagus as shown in fig. 24c. Two small ampullae in the corpus apparently mark the outlets of the submedian esophageal glands. The nucleus of the dorsal esophageal gland is easily seen near the middle of the bulb but the submedian gland nuclei are very small and obscure, one apparenty lying back near the base of the bulb. Anterior end of intestine bearing a distinct valvular apparatus. Ovary only 4 or 5 body widths long, containing about a dozen oöcytes arranged in single file. Anterior portion of oviduct serving as a spermatheca. The short uterus and oviduct combined are about as long as the ovary. Vulva a deep transverse slit. Posterior uterine branch vestigial, half as long as the body width. Males unknown but the two females collected both contained spermatozoa, therefore males probably exist.

Diagnosis: *Thada* with longitudinal as well as transverse striae.

Type Habitat: Soil from sugar-beet field, Fort Collins, Colorado; collected by John O. Gashill, U. S. Sugar Plant Investigations.

GENERA AND SPECIES OF DOUBTFUL POSITION

GENUS *HALENCHUS* COBB, 1933

Tylenchidae. Junction of esophagus and intestine indefinite. Terminus of tail ventrally hooked. Spear smaller in male. Marine.

Type Species: *Halenchus fucicola* (deMan, 1892) N. A. Cobb, 1933.

Synonym: *Tylenchus fucicola* deMan, 1892.

DeMan very plainly figures the elongated esophageal gland, with its large nucleus, extending back beside the intestine in a manner similar to that of *Deladenus durus*. The position of this genus is doubtful and until more definite information is available it is deemed best to leave it directly under the *Tylenchidae*.

Halenchus fucicola (deMan, 1892) Cobb, 1933

Plate IX, Fig. 26

♀: 1.25–1.45 mm; a = 45–50; b = 5–6; c = 11–13; V = 60–64.
♂: 1.10–1.25 mm; a = 45–60; b = 5–6; c = 11–13.

With characters of the genus. Cuticle with fine transverse striae. Spear 1/13 – 1/15 the length of the esopragus. Excretory pore at about

12%. Ovary outstretched. A short, rudimentary uterine branch present. Vulva with slightly elevated lips. Eggs about twice as long as body width. Testes outstretched. Bursa rising slightly anterior to spicula and extending to near middle of tail.

Host: *Fucus (Ascophyllum) nodosus*, a brown seaweed.

Distribution: East and west coast of Scotland, at Stonehaven and the mouth of the river Clyde, Ayshire coast and at Port Erin, Isle of Man. Specimens apparently identical but with slightly shorter neck. b = 6.6, collected at Woods Hole, Mass.

References: 5, 15.

Halenchus mediterraneus (Micoletzky, 1922) Cobb, 1933

Synonym: *Tylenchus mediterraneus* Micoletzky, 1922.

♀: 0.81 mm; a = 40; b = 7.8; c = 10.6; V — 69.5.
♂: 0.56–1.1 mm.

Similar in many respects to *H. fucicola* but smaller in size. Spear 1/9 – 1/7 the esophageal length. Bursa about three times as long as anal body diameter extending the same distance in front of the anus as behind it.

Habitat: Free-living among algae on the coasts of Mediterranean, Red Sea and Sea of Marmora.

References: 5, 18.

Tylenchus arboricolus Cobb, 1922

♀: 0.7 mm; a = 20; b = 12.5; c = ?; V — ^{70}87.
♂: 0.7 mm; a = 24; b = ?; c = 23.

Striae plain, about 1 μ apart except at extremities where they are closer together. Neck to the amalgamated lip region which is 7 μ wide and 2.5 μ high and set off by a constriction. Spear faintly knobbed. Esophagus with a vestigial, valveless, median swelling about half as wide as the neck. Length of esophagus questionable. Intestine thick walled. Tail of female straight, convex conoid to the acute symmetrical terminus. Ovary at first broad, then tapering to the blind end which is reflexed a short distance. Oöcytes generally arranged in an irregular manner.

Male tail resembling that of female. Spicula arcuate distally, straight in proximal part where they are two-fifths to one-third as wide as the body. Gubernaculum faintly developed if present at all. Bursa without ribs, rising two-thirds of body width in front of anus

and enveloping all but the very tip of the tail. Testis reflexed about three body widths.

Habitat: Numerous in blister-like structures on leaves of beech, *Fagus obliqua* Mirb., Santiago, Chile.

Unfortunately figures were not published with the description of this species. The indefinite ending of the esophagus and the apparent absence of an ovate valvular apparatus in the corpus of the esophagus indicate that it may be near to *Deladenus obesus.*

Anguillonema pinguicauda Fuchs, 1938

Plate IX, Fig. 27, 27a

♀: 0.632 mm; a = 27.5; b = 5.0; c = 22.5; V = 90.9.
♂: 0.501 mm; a = 33.0; b = 5.0; c = 19.0.

Spear with somewhat divided base. Esophagus with a large gland lying parallel to the basal bulb. Female tail tapering to a blunt, cylindrical or slightly clavate terminus. Spicula and gubernaculum tylenchoid. Bursa enveloping the tail.

Probably this species belongs in *Neotylenchus* but accurate designation is impossible without specimens.

ABBREVIATIONS USED IN ILLUSTRATIONS

al.....wings
amph.....amphidial apertures
br.....branch
brs.....bursa
ch.....chamber of corpus
cor.....corpus
gl sal dal...dorsal salivary gland
gub.....gubernaculum
jnc.....junction of intestine and esophagus
ncl.....nucleus of dorsal esophageal gland
nrv r.....nerve ring
oe gl op....esophageal gland opening
ov dct.....oviduct
on.....spear
ovr.....ovary
p ex.....excretory pore
ppl.....papillae
rud.....rudimentary
sp.....spiculum
spthc.....spermatheca
ut.....uterus
vlv.....vulva

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Plate I *

Fig. 1, 1a. *Neotylenchus abulbosus* Steiner. 1, anterior portion of body, x 400; 1a, posterior portion of male, x 600. After Steiner.

Fig. 2. *Neotylenchus consobrinus* (deMan). 2, head. After Goodey.

Fig. 3 – 3c. *Neotylenchus apiculatus* n. sp. 3, head; 3a, anterior portion of body; 3b, posterior portion of female; 3c, double flexure of ovary.

Fig. 4, 4a. *Neotylenchus latus* Thorne. 4, cephalic framework showing relative positions of papillae and amphids; 4a, posterior portion of female, x 375.

Fig. 5, 5a. *Neotylenchus obesus* Thorne. 5, head, x 1500; 5a, female tail, x 500.

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* Unless stated otherwise all lateral and *en face* figures of heads and cephalic frameworks are x 2000 and other portions of bodies are x 750.
All figures are original unless stated otherwise.

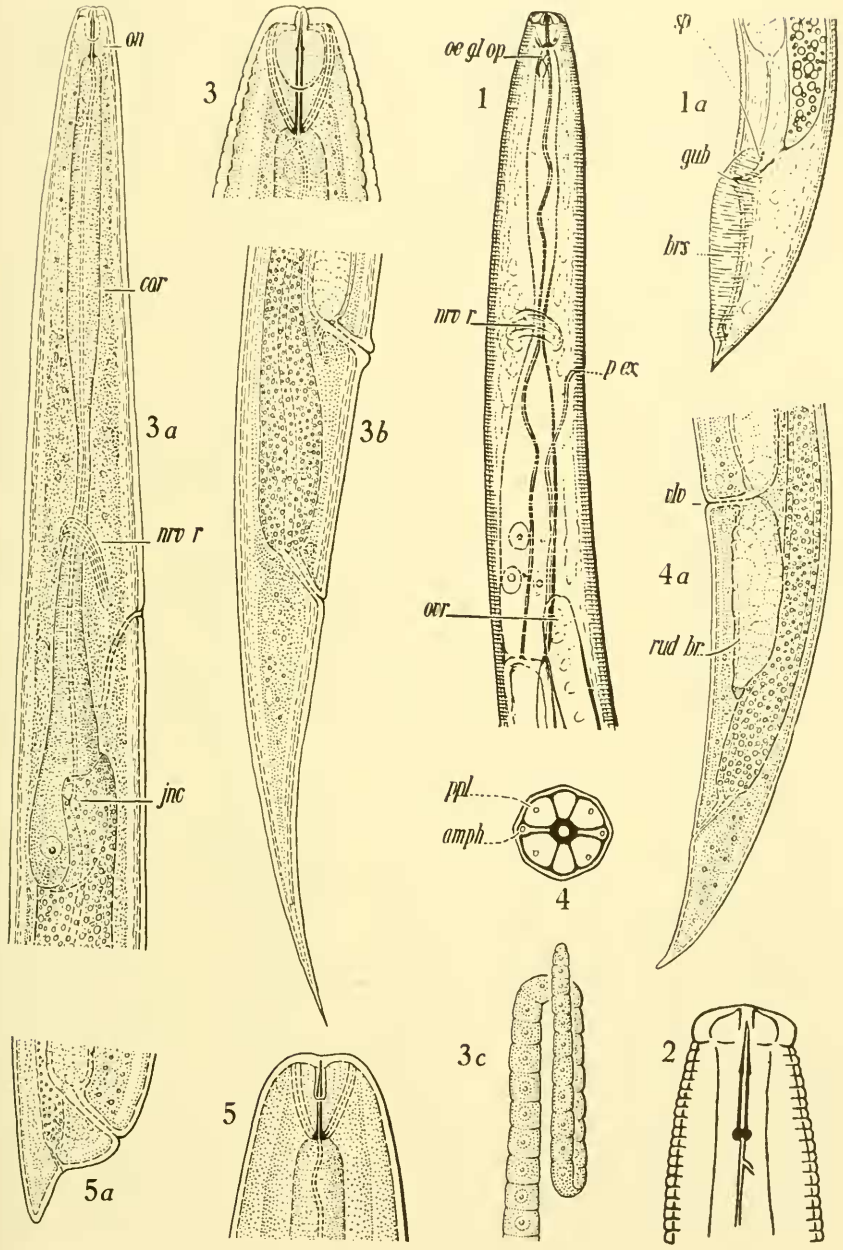
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PLATE I

Plate II

Fig. 6 – 6d. *Neotylenchus arcuatus* n. sp. 6, head, 6a, posterior portion of female, x 500; 6b, posterior portion of male, x 500; 6c, six lines of wing area; 6d, anterior portion of body.

Fig. 7 – 7i. *Deladenus durus* (Cobb). 7, anterior portion of body; 7a, *en face* of lip region; 7b, cephalic framework; 7c, ventral view of posterior portion of male, x 500; 7d, cross section of wing area, x 1000; 7e, head; 7f, posterior portion of female from Oregon; 7g, portion of intestinal lumen; 7h, posterior portion of female from *Pleurota* sp.; 7i, variations in termini of females from *Pleurota* sp.

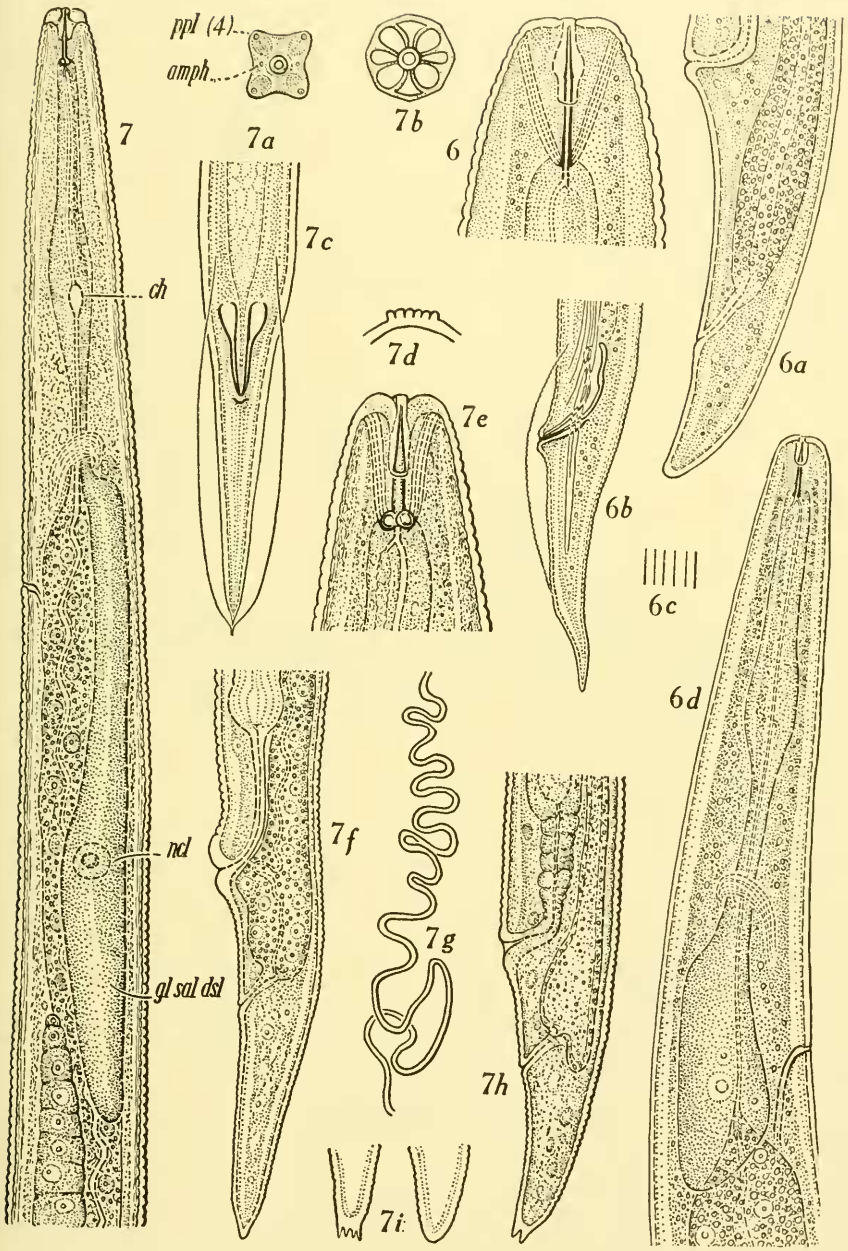

PLATE 11

Plate III

Neotylenchus intermedius (Christie), n. combt.

A – Female. B – Head, *en face* view. C – Tail of male, lateral and ventral views.

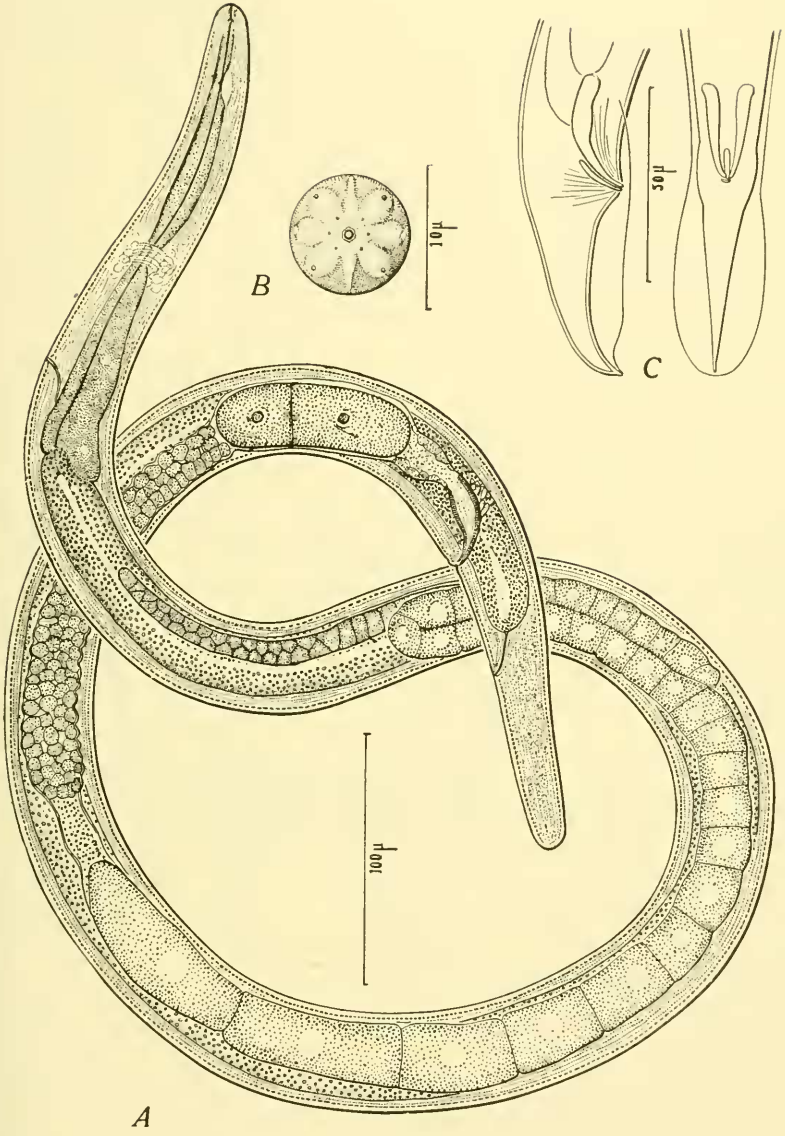

PLATE III

Plate IV

Fig. 8 – 8c. *Deladenus obesus* n. sp. 8, head; 8a, cephalic framework showing relative positions of papillae and amphids; 8b, anterior portion of body; 8c, posterior portion of body.

Fig. 9 – 9d. *Hexatylus vipiparus* Goodey. 9, *en face* of cephalic framework pattern; 9 a, cephalic framework; 9b, head; 9c, anterior portion of body; 9d, posterior portion of female, x 500.

Fig. 10 – 10a. *Hexatylus fungorum* (Bütschli). 10, posterior portion of female, x ?; 10a, posterior portion of male, x ?; After Bütschli.

Fig. 11 – 11b. *Iotonchium imperfectum* (Bütschli). 11, head; 11a, posterior portion of female; 11b, spiculum, x ? on all figures. After Bütschli.

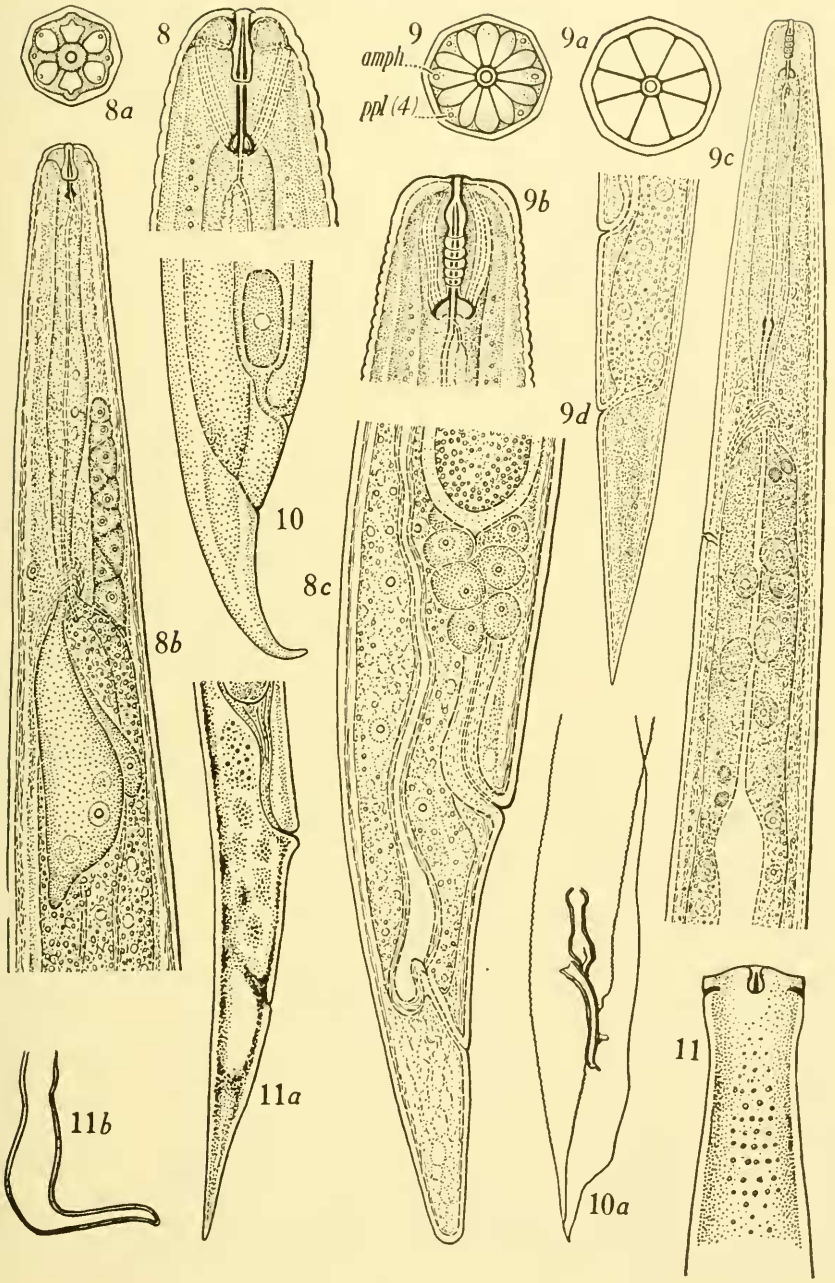

PLATE IV

Plate V

Fig. 12 – 12c. *Paurodontus gracilis* n. sp. 12, *en face*; 12a, anterior portion of body; 12b, posterior portion of male; 12c, posterior portion of female; 12d, cephalic framework.

Fig. 13 – 13d. *Paurodontus densus* n. sp. 13, *en face*; 13a, anterior portion, x 1500; 13b, posterior portion of female, x 1000; 13c, section showing wing area, x 1000.

Fig. 14 – 14d. *Paurodontus apiticus* n. sp. 14, anterior portion of body, x 1000; 14a, reproductive system of female from the vulva through the oviduct; 14b, posterior portion of female, x 500; 14c, oviduct of very young female; 14d, head.

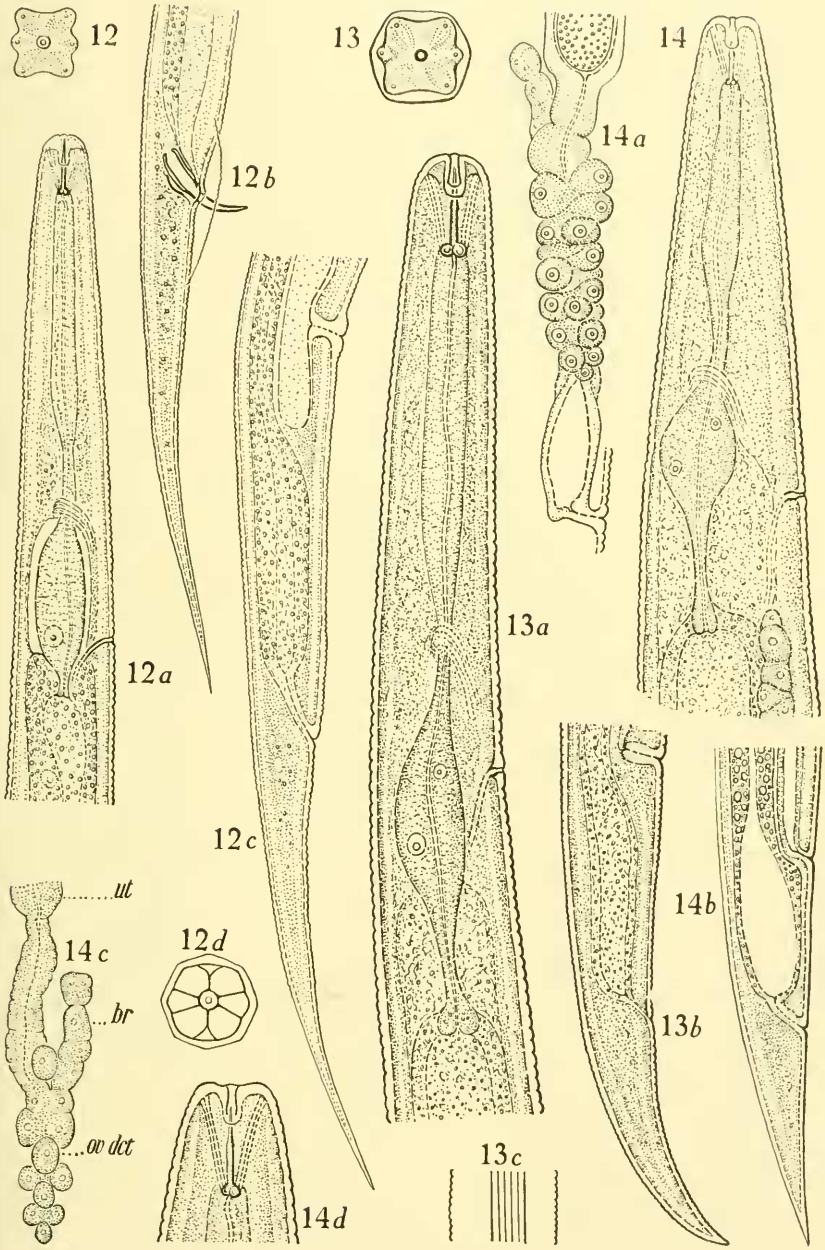

PLATE V

Plate VI

Fig. 15, 15a. *Paurodontus niger* n. sp. 15, anterior portion of body, x 1000; 15a, posterior portion of female.

Fig. 16 – 16f. *Stictylus asymmetricus* n. sp. 16, *en face;* 16a, head; 16b, variation in basal esophageal bulb; 16c, posterior portion of body; 16 e, posterior portion of male; 16f, section showing wing area.

Fig. 17, 17a. *Stictylus obtusus* n. sp. 17, anterior portion of body; 17a, posterior portion of female, x 500.

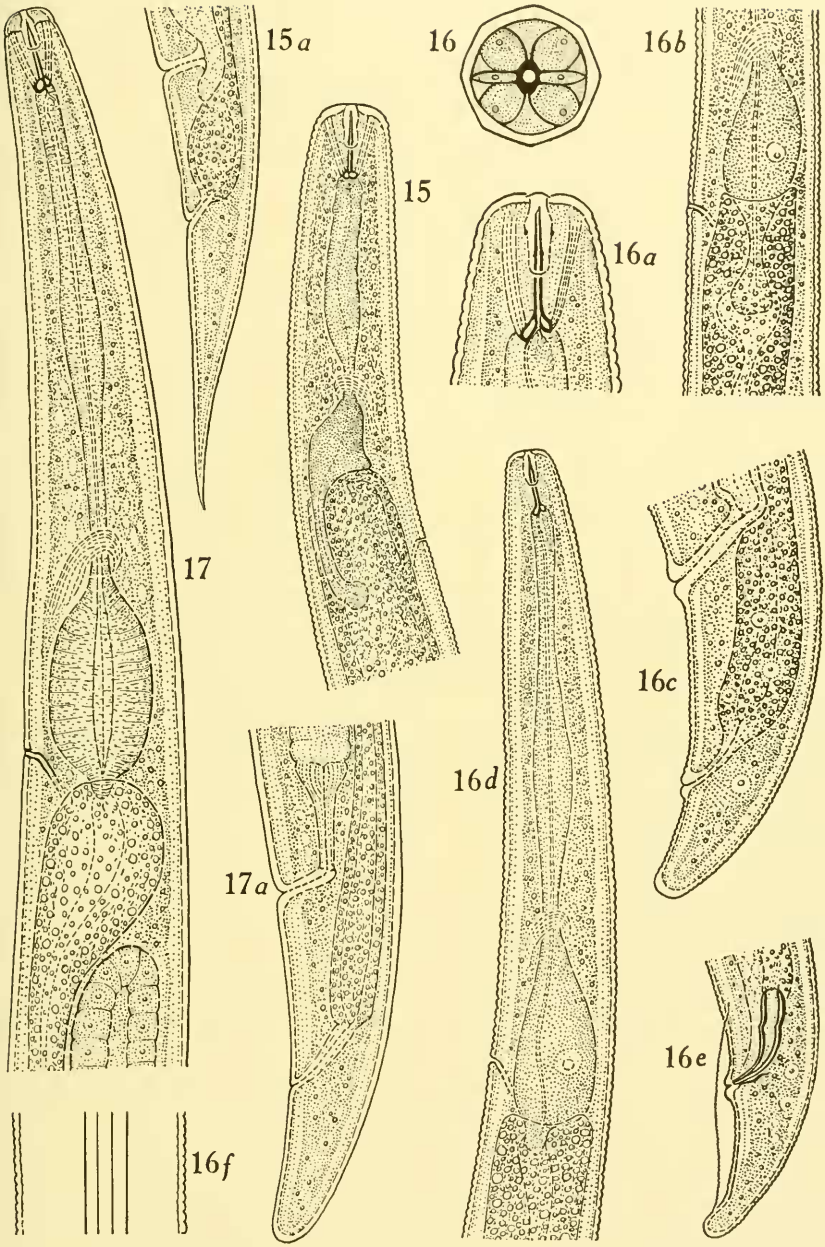

PLATE VI

Plate VII

Fig. 18 – 18c. *Nothotylenchus acris* n. sp. 18, anterior portion of body; 18a, posterior portion of female; 18b, posterior portion of male; 18c, body section showing wing area.

Fig. 19 – 19c. *Nothotylenchus affinis* n. sp. 19, head; 19a, cephalic framework; 19b, posterior portion of female; 19c, posterior portion of male, a1, adjacent section of wing area.

Fig. 20, 20a. *Nothotylenchus cylindricollis* n. sp. 20, anterior portion of body; 20a, posterior portion of female.

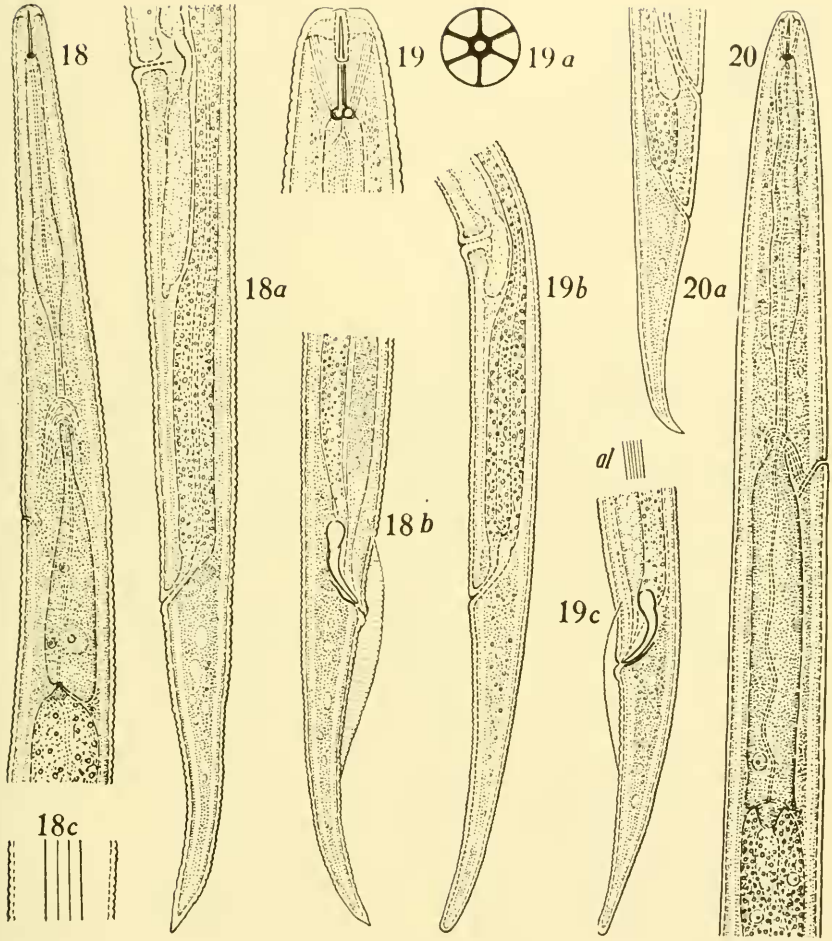

PLATE VII

Plate VIII

Fig. 21 – 21h. *Bolcodorus thylactus* n. sp. 21, cephalic framework; 21a, *en face;* 21b, head; 21c, amphidial system in profile as seen when stained by neutral red; 21d, dorso-ventral view of corpus showing outlets of submedian esophageal glands; 21e, section through spear base, x 2000; 21f, anterior portion of body, x 1000; 21g, posterior portion of female, x 500; 21h, posterior portion of male, x 1000.

Fig. 22 – 22b. *Bolcodorus clavicaudatus* n. sp. 22, head; 22a, female tail; 22b, portions of esophagus and intestine.

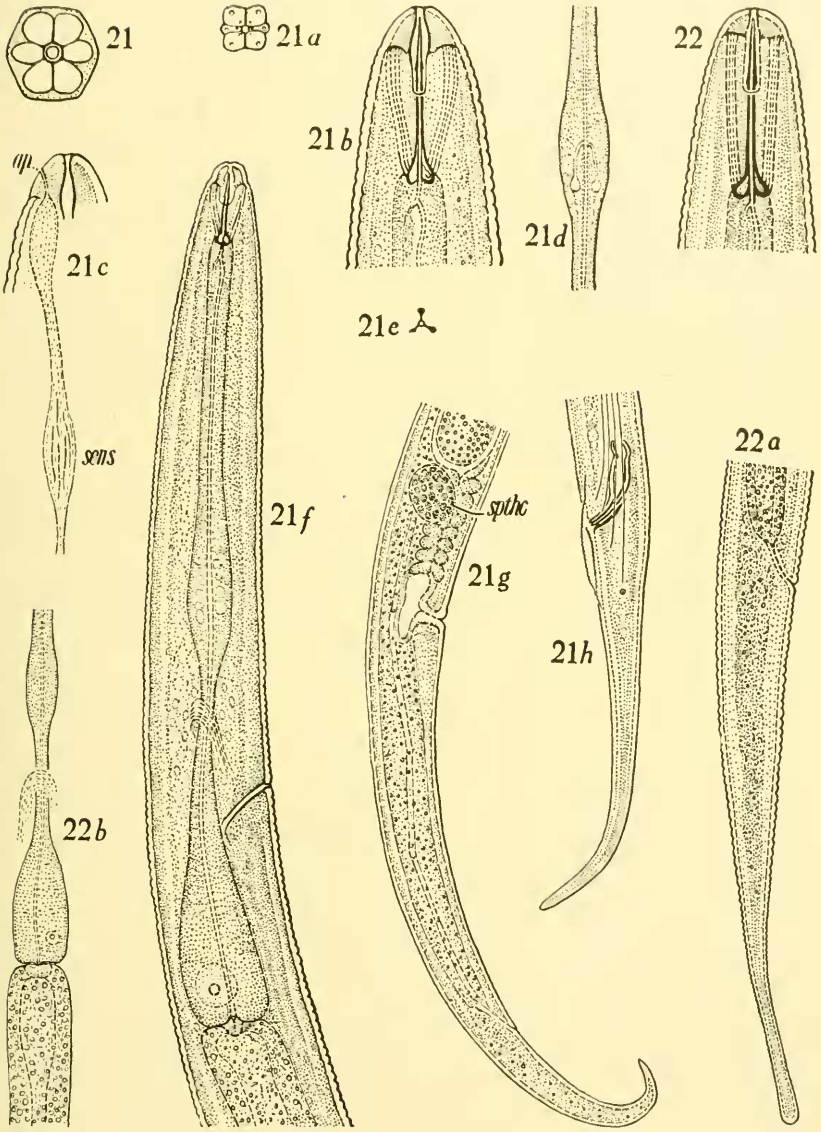

PLATE VIII

Plate IX

Fig. 23 – 23e. *Thada striata* n. sp. 23, *en face;* 23a, head; 23b, posterior portion of male, x 1000; 23c, anterior portion of body, x 1000; 23d, posterior portion of female, x 1000; 23e, posterior portion of diseased female, x 1000.

Fig. 24 – 24c. *Thada cancellata* n. sp. 24, head; 24a, anterior portion of body, x 1200; 24b, posterior portion of female, x 1200; 24c, esophageal system, x 1200.

Fig. 25. *Neotylenchus coprophagus* Goodey. 25, anterior portion of body, x 900. After Goodey.

Fig. 26. *Halenchus fucicola* (deMan). 26, characteristic hooked terminus. After deMan.

Fig. 27, 27a. *Anguillonema pinguicauda* Fuchs. 27, anterior portion of body, x 700; 27a, posterior portion of female, x 700. After Fuchs.

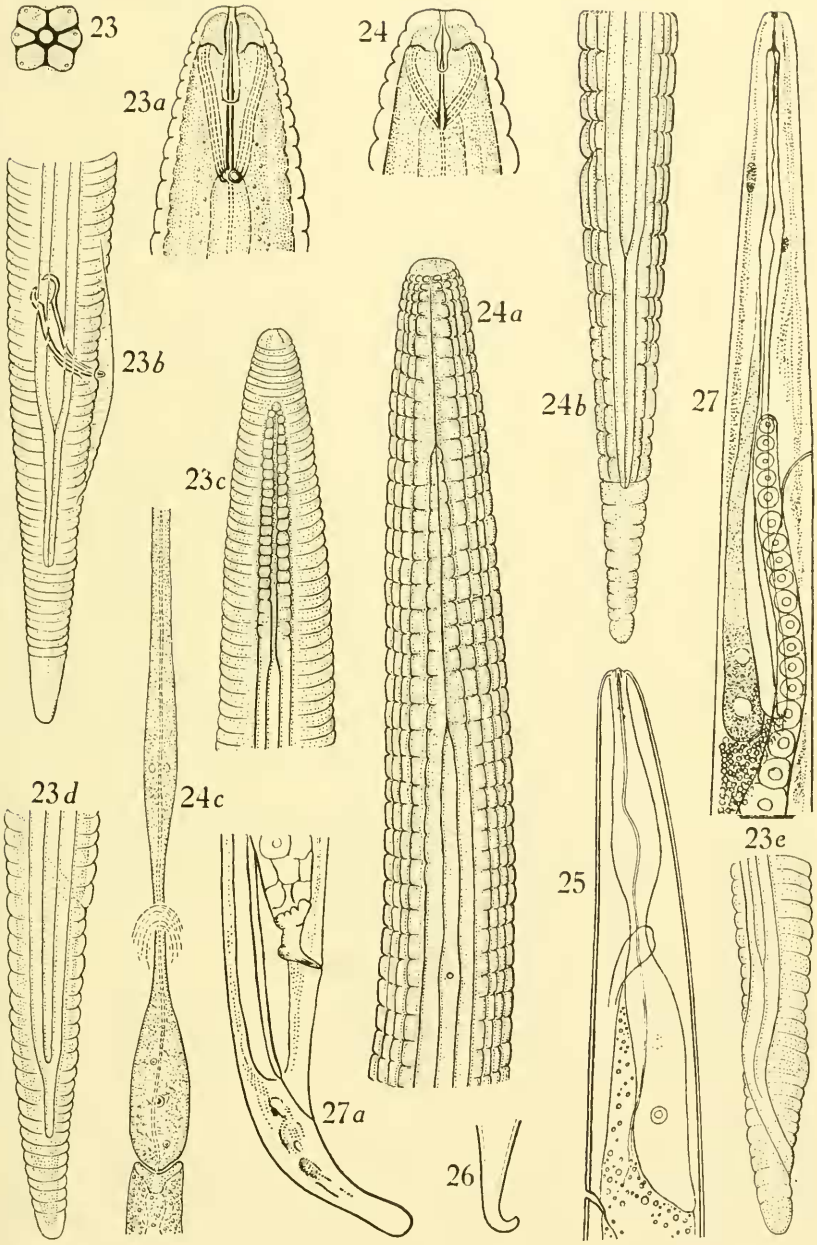

PLATE IX